EV Market Analysis Report

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Dt. 11/01/2024

The surge in Electric Vehicle (EV) adoption in India is not merely a consequence of global environmental concerns but also a response to the pressing challenges faced by the nation. As one of the fastest-growing economies, India grapples with issues like air pollution, fuel price volatility, and energy security. The government's push towards a sustainable future is evident through various policy initiatives and incentives designed to accelerate the transition to electric mobility.

The National Electric Mobility Mission Plan (NEMMP) and Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme are emblematic of India's commitment to fostering a conducive ecosystem for EVs. These policies aim to incentivize both manufacturers and consumers, creating an environment where electric vehicles are not only environmentally friendly but economically viable.

The increasing availability of a diverse range of electric vehicles, from compact urban models to larger SUVs, further reflects a maturing market catering to varied consumer needs. Moreover, advancements in battery technology, reductions in production costs, and a growing charging infrastructure contribute to the overall appeal of EVs.

However, the market is not without its challenges. Range anxiety, the limited availability of charging infrastructure, and the cost of electric vehicles are hurdles that prevent faster adoption of EVs. But India is slowly addressing these problems. Investment in charging stations is increasing and the charging infrastructure is rapidly increasing. This has helped alleviate some of the anxiety regarding the range of the EVs.

For the purpose of the Market Analysis regarding the existing EV Market we conduct an analysis on the spending of people across different demographics on conventional vehicles, to extrapolate possible spending on EVs. We will also use the data available on the number of EVs in India in different states across various categories, to find the optimum market segment for EVs. The market size for EVs in India in the year 2022 was about $ 3.21 billion and is expected to grow to around $113 billion in 2030. In the year 2023 around 4 to 5 lakh 4 wheeler EVs were sold in India which has a steady 2% growth rate over the previous year.

Indian Automobile buying behavior:

The first dataset consisted of the automobile buying behavior of Indian customers. It consisted of different data points such as age, education, marital status of the customers along with a myriad of other data. Fig 1 shows a sample of the dataset used.

	Age	Profession	Marrital Status	Education	No of Dependents	Personal loan	House Loan	Wife Working	Salary	Wife Salary	Total Salary	Make	Price
0	27	Salaried	Single	Post Graduate	0	Yes	No	No	800000	0	800000	i20	800000
1	35	Salaried	Married	Post Graduate	2	Yes	Yes	Yes	1400000	600000	2000000	Ciaz	1000000
2	45	Business	Married	Graduate	4	Yes	Yes	No	1800000	0	1800000	Duster	1200000
3	41	Business	Married	Post Graduate	3	No	No	Yes	1600000	600000	2200000	City	1200000
4	31	Salaried	Married	Post Graduate	2	Yes	No	Yes	1800000	800000	2600000	SUV	1600000

Fig 1: Sample of dataset

For the purpose of preliminary analysis we picked 4 variables Age, Number of Dependents, Total Salary and Price. Fig 2 consists of the pair plots for these variables.

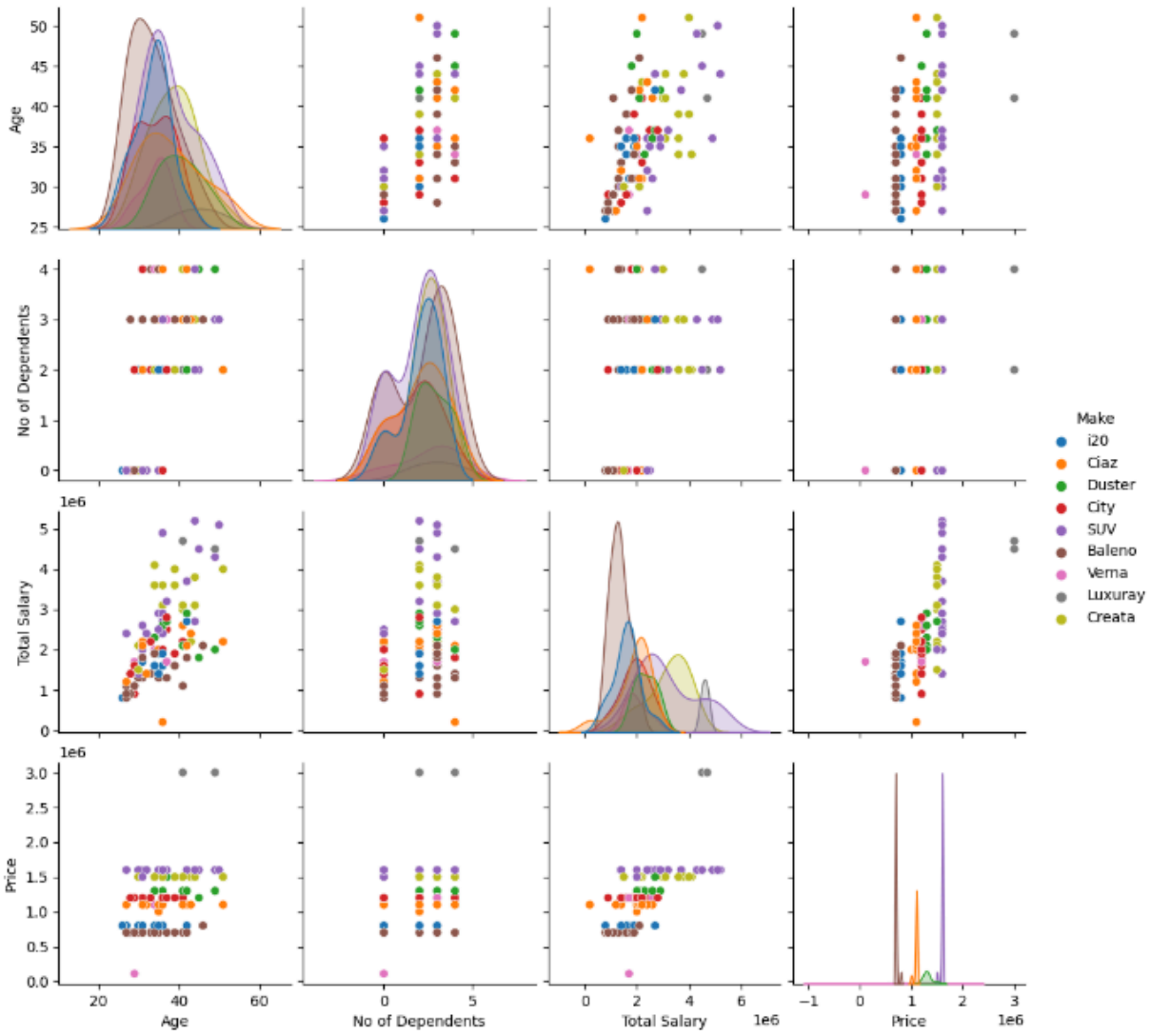

Fig 2: Pair plots for Age, Number of Dependents, Total Salary and Price

We can infer some information from these plots such as the total salary increased with the age and that the person having more salary also bought a more expensive car. In order to get more concrete inferences we used the Spearman Correlation Heatmap to get detailed dependencies of the variables.

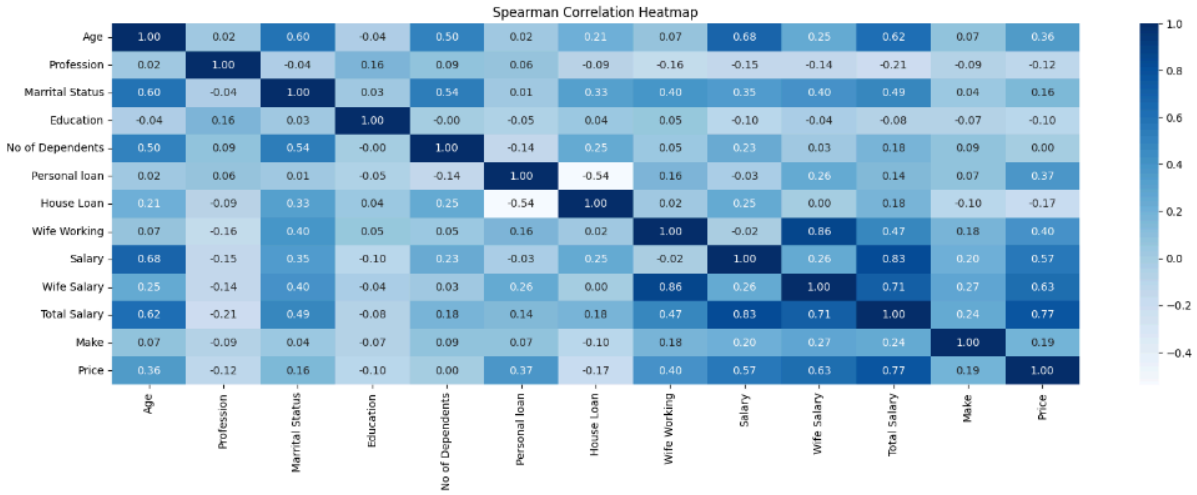

Fig 3: Spearman Correlation Map

From the figure above we can see that the total salary is strongly linked to the person's salary and the salary of his wife. It is also strongly dependent on the age of the person. The number of dependents also rely on the marital status of the person. To conduct an effective segmentation we use Principal Component Analysis to summarize the given data. We use 8 components Age, Profession, Marital Status, Education, Number of Dependents, Personal and House Loans and Working Status of Wife.

	1	2	3	4	5	6	7	8
Age	0.99	-0.12	0.01	-0.00	0.01	-0.00	-0.01	-0.01
Profession	0.00	0.03	-0.03	-0.57	0.38	0.73	-0.03	-0.01
Marrital Status	0.03	0.12	-0.11	0.21	0.10	0.12	0.24	0.92
Education	-0.01	0.02	0.02	-0.06	0.87	-0.49	0.02	-0.02
No of Dependents	0.12	0.97	-0.11	-0.11	-0.08	-0.09	-0.04	-0.09
Personal loan	0.00	-0.10	-0.66	-0.18	-0.07	-0.10	0.69	-0.19
House Loan	0.01	0.14	0.55	0.36	0.13	0.25	0.63	-0.25
Wife Working	0.00	0.05	-0.48	0.67	0.26	0.36	-0.26	-0.23

	PC-1	PC-2	PC-3	PC-4	PC-5	PC-6	PC-7	PC-8
Standard Deviation	39.61	1.29	0.33	0.31	0.27	0.17	0.10	0.05
Proportion of Variance	0.94	0.03	0.01	0.01	0.01	0.00	0.00	0.00
Cumilative Proportion	0.94	0.97	0.98	0.99	0.99	1.00	1.00	1.00

Fig 4: PCA and Cumulative proportion of each component

The rest of the variables were omitted in this part of the analysis to study the effect of other variables on the segmentation analysis and to determine whether they hold any significance. From the Second Table we can observe that Age alone explains 94% of variation in the dataset.

For Market segmentation we use the K-means algorithm.It was developed by Stuart Lloyd in 1957, is a popular clustering method used for data analysis and machine learning. It partitions a dataset into clusters based on similarities among data points. The algorithm iteratively follows two main steps until convergence:

1. Initialize **cluster centroids** $\mu_1, \mu_2, \ldots, \mu_k \in \mathbb{R}^n$ randomly.
2. Repeat until convergence: {

   For every i, set
   $$c^{(i)} := \arg\min_j \|x^{(i)} - \mu_j\|^2.$$

   For each j, set
   $$\mu_j := \frac{\sum_{i=1}^{m} 1\{c^{(i)} = j\} x^{(i)}}{\sum_{i=1}^{m} 1\{c^{(i)} = j\}}.$$

   }

The algorithm aims to minimize the within-cluster sum of squares by finding optimal cluster centroids. While it is computationally efficient, it is sensitive to initial centroid placement, often requiring multiple runs with different initializations to achieve robust results. K-means has applications in diverse fields such as image segmentation, customer segmentation, and pattern recognition.

On running K-Means on different number of clusters we got the following graph:

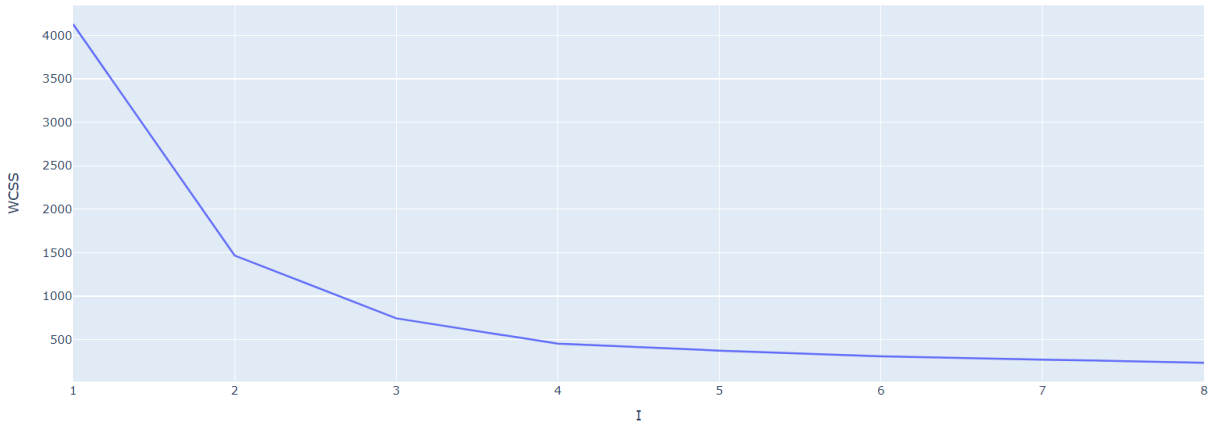

Fig 5: Elbow Graph for K-Means

We choose the value 4 for the number of our clusters. Fig 6 shows the various cluster assignments for the data points.

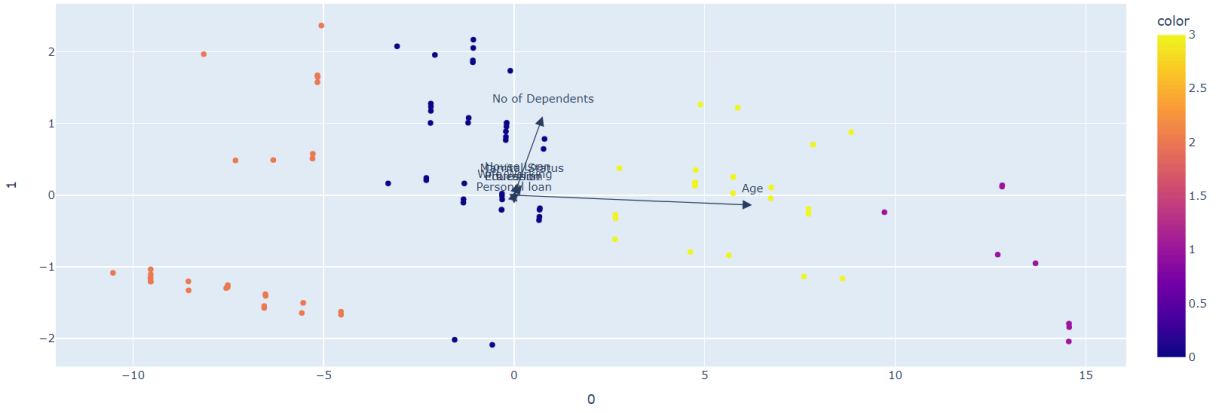

Fig 6: Cluster Assignments

We then combine these cluster assignments with the Total Salary and price of the car to gain further insight into the buying behavior of the Indian customers. We use two scatter plots. The first scatter plot in Fig 7 shows the relation between the age and the total salary for each cluster while the bubble size is indicative of the mean price of the vehicles in each cluster. We can see that the total salary increases with age and there is a slight increase in bubble size as well.

Fig 8 shows the relation between the price of the car in each cluster with the mean number of dependents in each cluster. The bubble size represents the total salary. We can see from the figure people who have dependents tend to buy a more expensive car to comfortably accommodate the dependents.

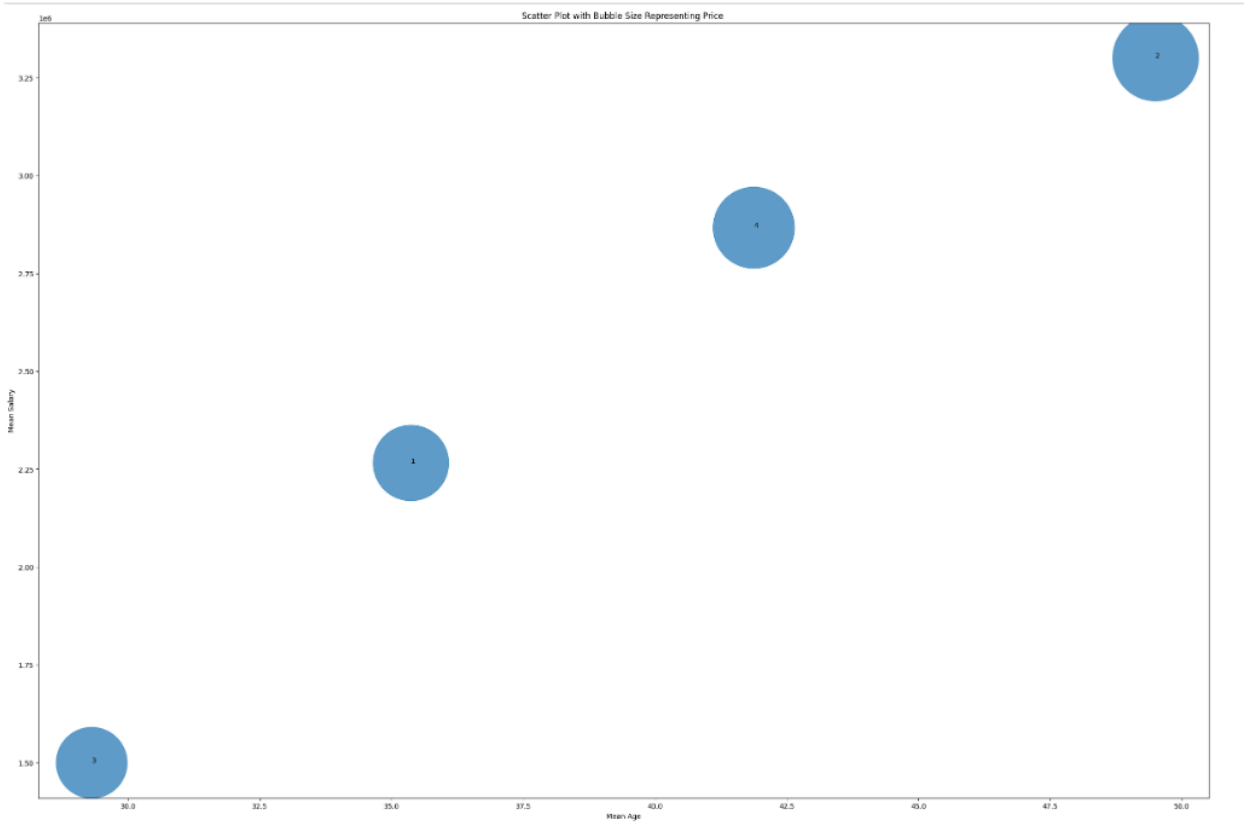

Fig 7: Scatter Plot for Age v/s Salary

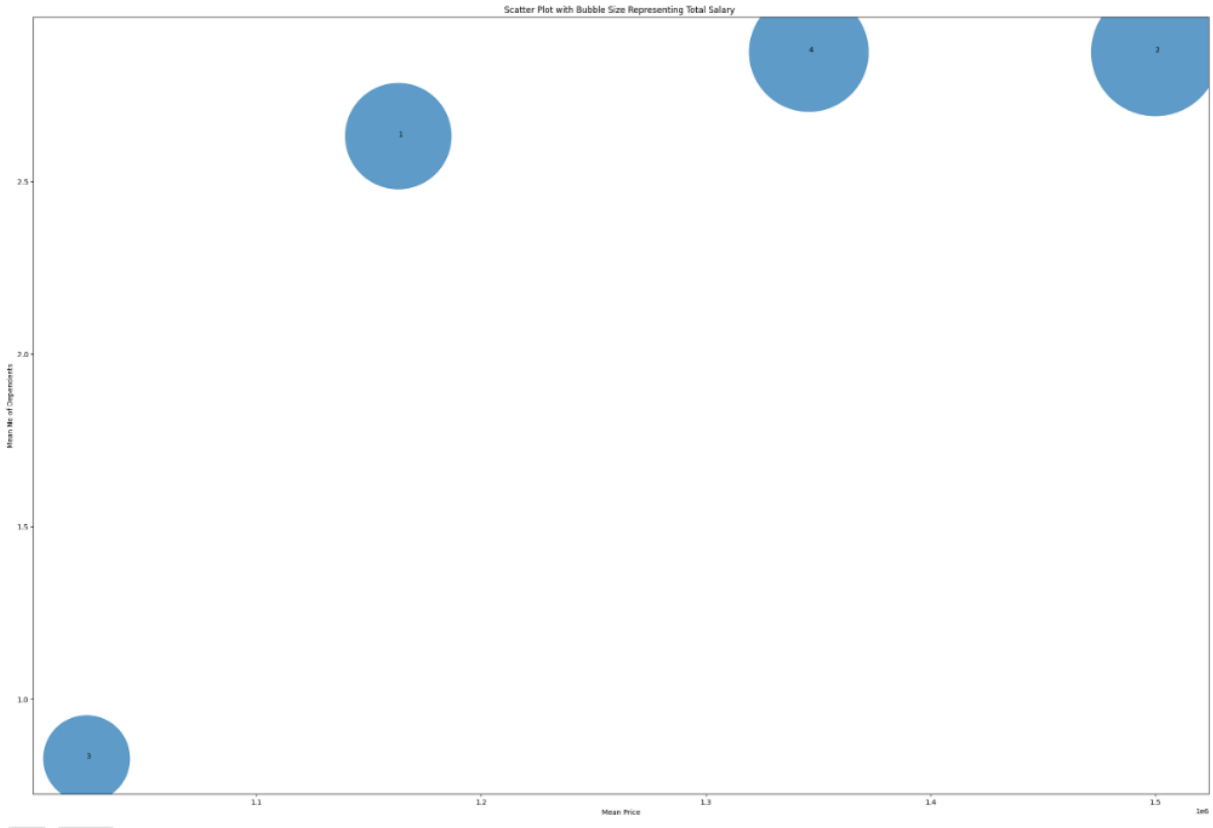

Fig 8: Scatter plot for Price v/s Number of dependents

We use the data available regarding the sales of EVs in India to determine the geographical segments for EV sales. The following Pie chart shows the sale of EVs in each state. A threshold of 5% was applied to display individual states.

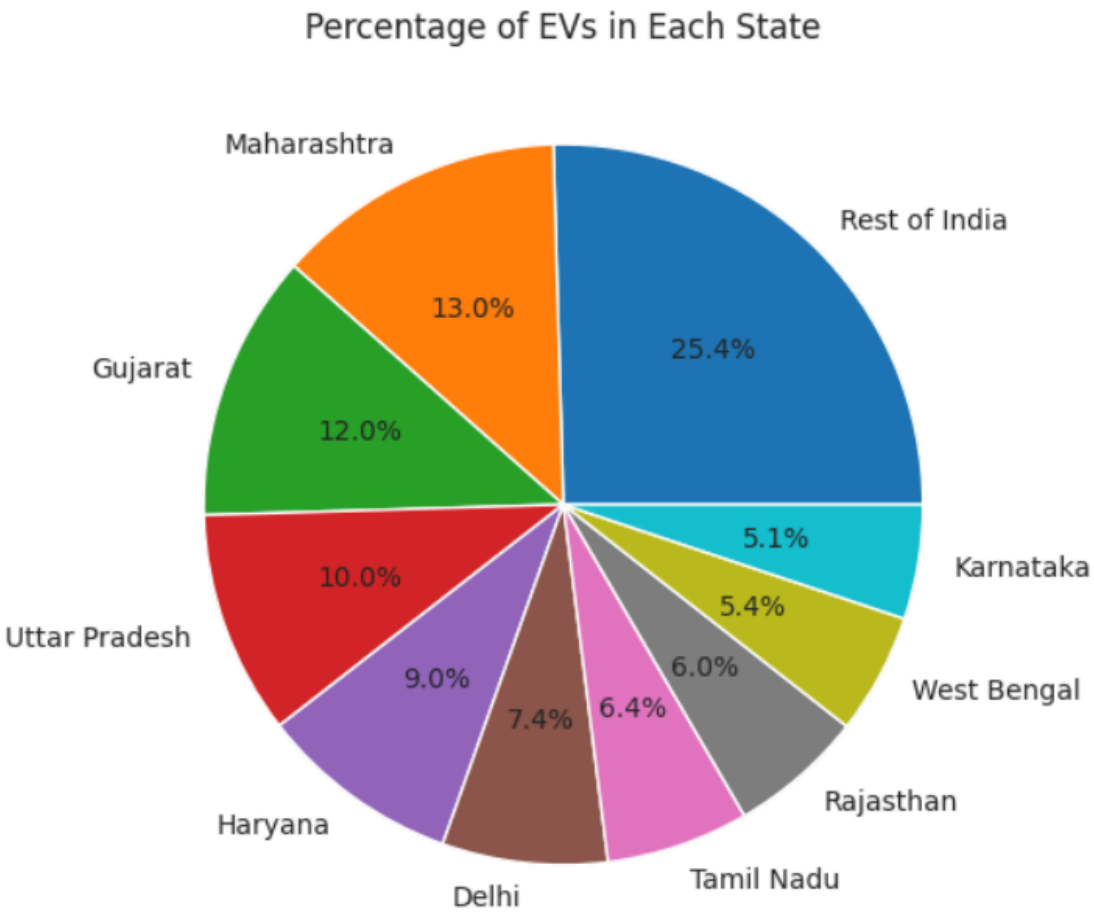

Fig 9: EV sales in each State

We can observe from the chart that only 4 states and 1 UT are responsible for half of the sales in India. Further, 8 states plus 1 UT account for $3/4^{th}$ sales of EVs in the country making them extremely desirable for targeting in any sales strategy. Fig 10 shows the different categories of EVs that were sold.

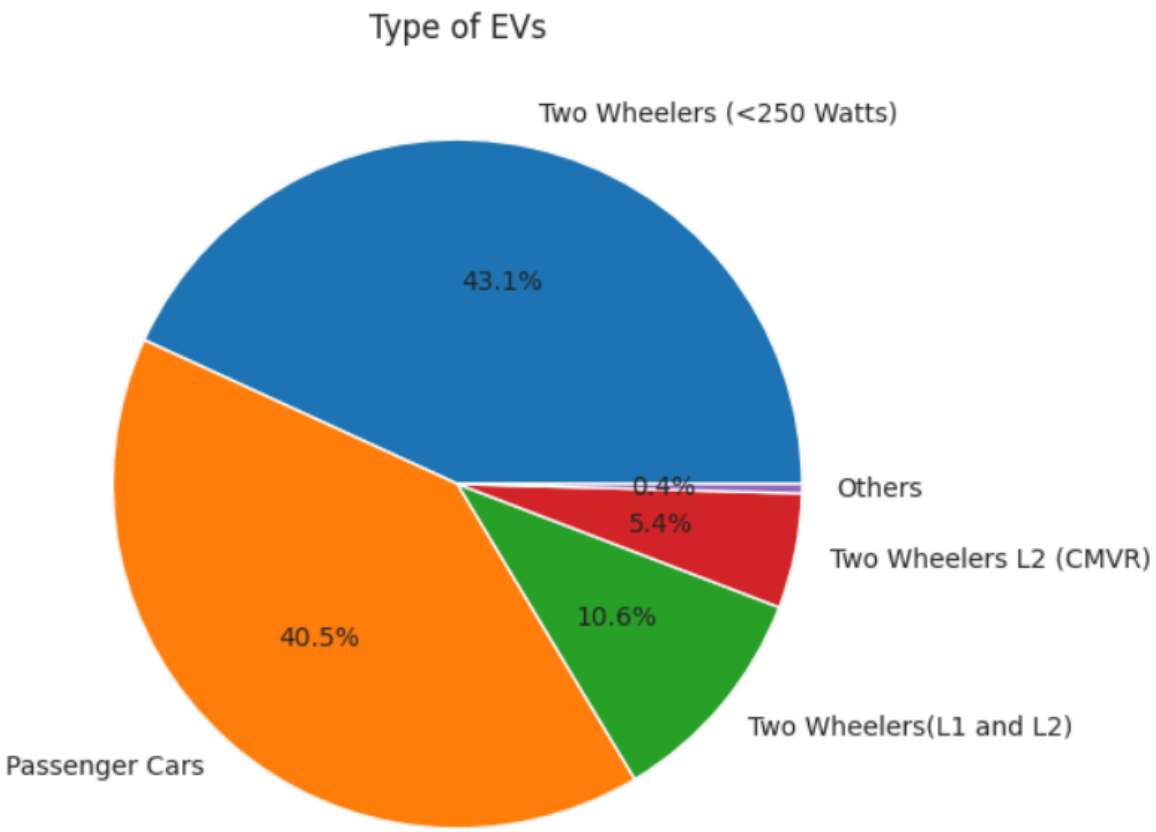

Fig 10: Types of EVs sold

We can observe from the chart that almost all of the vehicles sold fall in either 2W or 4W category, with the 2W category accounting for a majority of sales at 59%.

The biggest challenge of conducting a market segment analysis is the lack of publicly available data regarding the exact specs of EVs sold in India and the buying habits of Indians when it comes to EVs. We can try to extrapolate the behavior using conventional vehicles but a dataset regarding EVs will be more insightful and helpful. Further we also need data regarding sales in cities, urban and rural areas and different demographics. Currently we only have state and category data.

Salary and Age are one of the important factors while conducting the market analysis. But when it comes to EVs, we also need to know the geographical locations of all available charging stations within a certain radius of potential customers. Also we need to ensure that the state that customer is living in has robust charging infrastructure to enable not only intra city travel but also inter city and possibly inter state travel when it comes to 4 wheelers. For 2 wheelers, the vehicle should either have a longer range and /or a robust charging infrastructure should be present in that area. Range is also a defining factor in the adoption of EVs. In conventional cars,

you have petrol/diesel stations readily available, but that is not the case for EVs. All of the above factors combined with the price of the EVs can also affect the choice of customers as it has to compete with conventional cars in the similar price range.